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A MEMORANDUM

ON THE

MEASUREMENT OF MOVEMENTS OF JOINTS.

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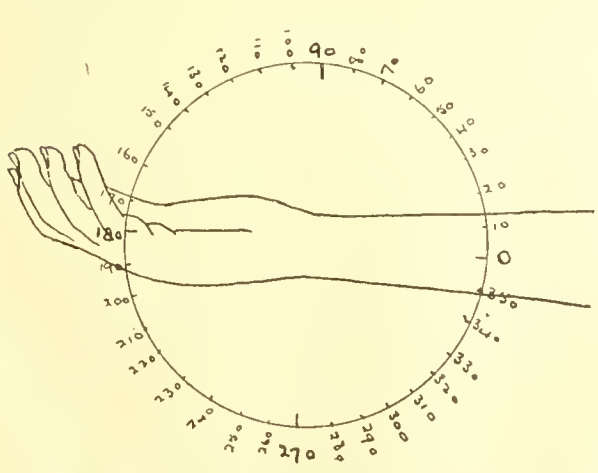
A MEMORANDUM ON THE MEASUREMENT OF MOVEMENTS OF JOINTS.

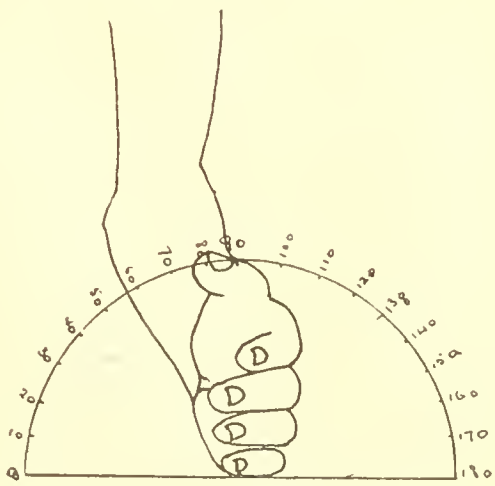
Capt. R. I. Harris, M.C., C.A.M.C.

The lack of uniformity in the methods of measuring and recording movements of joints leads to much confusion at a time like the present, when it is necessary accurately to describe disabilities of soldiers. The universal adoption of some standard system of measurement would provide a means (1) of accurately examining and recording the disabilities of soldiers, (2) of accurately following their progress under treatment, (3) of enabling one to judge the value of various forms of treatment, and (4) of describing the man's condition for the information of the Board of Pension Commissioners in terms which would be universally understood. The value of such a system lies not so much in the method employed as in its universal adoption. It is with a view to supplying this lack that the following memorandum was drawn up.

Any such system of measurement of limitations of movements in order to be universally adopted, must be simple and require a minimum of instruments. In consequence, in compiling this memorandum the end which has been kept in view has been simplicity, combined with reasonable accuracy. Greater accuracy might have been obtained by the use of special instruments for each movement, but this would involve the use of such a multiplicity of instruments that the system would be valueless anywhere but in elaborately equipped institutions. Moreover, it should be borne in mind that even with the most elaborate instruments it is not possible to make absoultely accurate measurements of some movements of some joints.

For the attainment of simplicity it is necessary to lay down certain arbitrary principles and definitions. The confusion arising from the ambiguity of certain terms (e.g., supination and pronation) is thus avoided. For the same reason, it has been considered better to read in the same way the measurements of similar movements at different joints (e.g., angles of flexion in degrees less than 180°, and angles of extension in degrees greater than 180°, where these movements take place on both sides of the straight line). This principle can be visualized conveniently by imagining the joint whose range of movement is to be measured, to be the centre of a circle whose circumference is divided into 360 degrees. The distal element of the joint moves through a greater or smaller arc of this circle. The degrees on the circumference are numbered in such a fashion that those on the flexion side range from 0 degrees to 180°, and those on the extension side from 180° to 360°. In addition to simplifying the measurement of the range of movements, this principle permits the position of ankylosis, in ankylosed joints, to be accurately defined. The same principle applies to movements of rotation, except that their mid-position is considered as 90° instead of 180° and the movements of internal rotation (including pronation) range down to 0°, and movements of external rotation (including supination) range up to 180°. The accompanying sketches and the diagrams for graphic records on pp. 5 to 7 illustrate this point.





The measurement of the ranges of movements of the fingers presents difficulties, in that it requires a disproportionate expenditure of time and energy and a special instrument. In many cases it is sufficient for practical purposes to state that such and such movements are present and to estimate their extent in fractions of the normal. In other cases, however, it is important to know the range of movement of at least the metacarpo-phalangeal joints. For this purpose a small goniometer renders the problem of their measurement easy.

For practical purposes the following movements of the foot, adduction–abduction and supination–pronation, and all the movements of the spine, may be estimated in terms of normal without any attempt at more accurate measurement.

The fundamental definitions and principles underlying this system of measurement, as well as the instruments necessary for its use, may be outlined as follows.

Definitions.

1. Movements of Flexion and Extension.

With the patient in the anatomical position (i.e., erect, with arms by the side and palms of the hands turned forward) all movements of joints (with the exception of those of the knee

and ankle) which move the distal elements of the joints forwards in the antero-posterior plane are movements of flexion; and the converse, movements of extension. In the case of the knee the rule is reversed; in movements of flexion the distal element of that joint is moved backwards and in movements of extension, the converse. In the case of the ankle, there exists so much confusion with regard to the nature of the terms flexion and extension that it is well to avoid any ambiguity by designating movements of the foot forwards and upwards as dorsi-flexion, and movements of the foot backwards and downwards as plantar-flexion.

2. Movements of Adduction and Abduction.

With the patient in the anatomical position, all movements of the limb in a lateral plane towards the mid-line of the body (in the case of the fingers, towards the mid-line of the hand), are movements of adduction; and the converse, movements of abduction.

3. Movements of Rotation.

With the patient in the anatomical position, all rotary movements of limbs, or segments of limbs, about their long axis, which turn the anterior surface in towards the mid-line of the body are movements of internal rotation (pronation in the case of the forearm and foot); and the converse, movements of external rotation (supination in the case of the forearm and foot). Because of the looseness with which they are employed, the terms supination and pronation need to be further defined. At least three definitions are open, all of which possess certain features which recommend them for use. In adopting the following definition consideration has been paid to common usage of the terms in the past.

The Mid Position of the forearm between the extremes of supination and pronation is one in which the palm of the hand faces inwards towards the mid-line of the body.

Pronation is the internal rotation of the forearm from the mid-position to the extreme limit to which internal rotation is possible.

Supination is the external rotation of the forearm from the mid-position to the extreme limit to which external rotation is possible.

Principles.

1. The function to be measured is the movement of the distal element of a joint in various planes rather than the contractility of certain muscles or groups of muscles controlling the joint.

2. The angle to be measured is the angle formed between the two elements entering into the formation of the joint and not the angle between the present position and some previous position of one element of the joint. This means that when two elements of a joint are in a straight line with one another (e.g., elbow and knee in full extension), the record on the scale is 180°.

Exceptions to this rule must be made in the case of (1) all movements of rotation (see definition 3), (2) the movement of adduction-abduction at the shoulder, where it is more convenient to consider the side of the trunk rather than the scapula, as one limb of the angle, and (3) the movement of adduction–abduction at the hip, where, for the same reason, it is more convenient to use the interspinous line than the side of the trunk, as a base from which to measure.

3. In the case of joints in which there is movement on both sides of the straight line (e.g., wrist) it is convenient to regard angles of flexion as being less than 180°, and angles of extension as being greater than 180°. The acceptance of this arbitrary principle renders the measurement of the range of movement a simple matter of subtraction of one angle from another and the description of the position of fixation of a joint a simple statement of its angle.

4. In the case of movements of rotation it is necessary to find some structure which will serve as a pointer or index of the degree of rotation and act as a line from which to measure. For the arm the amount of rotation may be conveniently indicated by the forearm flexed to 90° at the elbow. Any rotation of the arm then swings the forearm with it. In a similar fashion the line of the palm of the extended hand serves as a pointer to indicate the amount of rotation of the forearm; and the centre line of the foot flexed 90° at the ankle, serves as a pointer to indicate the amount of rotation of the leg.

The angles that are measured in these movements of rotation are the angles between the long axes of the pointers and a base-line parallel to the ground. The mid-position is thus one of 90°. For the sake of uniformity it is convenient to measure movements of internal rotation and pronation in degrees less than 90°; and the angles of external rotation and supination in degrees greater than 90°.

5. In the description of disabilities of the fingers, name the fingers commencing from the thumb as follows: thumb, index, middle, ring, little.

6. In the description of disabilities of the toes, number the toes commencing from the inside as follows: one (great), two, three, four, five (little).

7. State the RANGE of motion as well as the extreme angles of flexion and extension. By this means the amount of movement is conveniently summed up, and errors in measurements due to observations by different persons are eliminated, the personal error tending to be in the same direction at both extremes.

8. Measure the passive as well as the active range of movements. By this means some indication is given as to whether the limitation of movement is bony or fibrous, and in joints whose controlling muscles are paralyzed, the passive range gives the only possible indication of the condition of the joint.

9. Record as in the following example:—

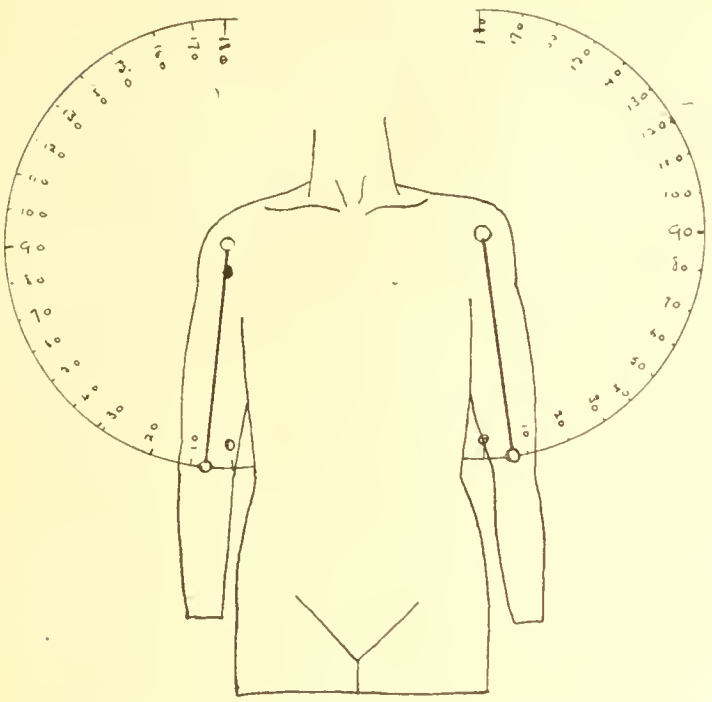
Elbow, right.—Flexion–Extension.

A.G.F. active 40°.	A.G.E. active 160°.	Range, active 120°.
passive 30°.	passive 175°.	passive 145°.

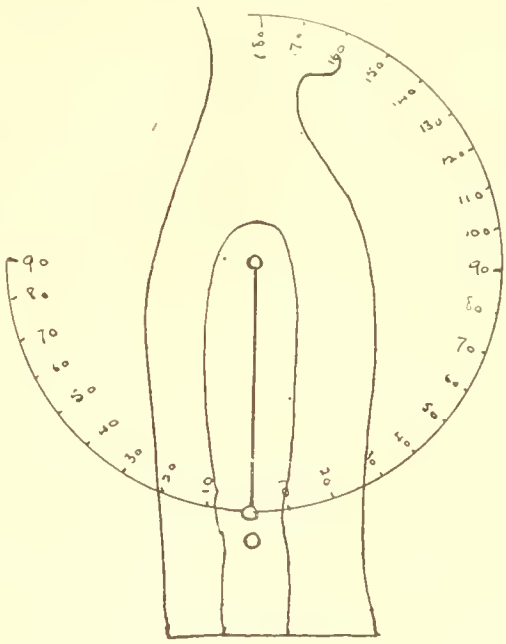
N.B.—A.G.F = angle of greatest flexion. A.G.E. = angle of greatest extension.

In addition, it is often convenient to record graphically the range of movement of a joint. This has the advantage of visualizing, better than figures, the appearance of the man's disability. Figures, on the other hand, give a more accurate record than diagrams. For graphic records a set of diagrams such as the following (adapted from those in use in a Military hospital in

No. 1. Shoulder.
Abduction–adduction.

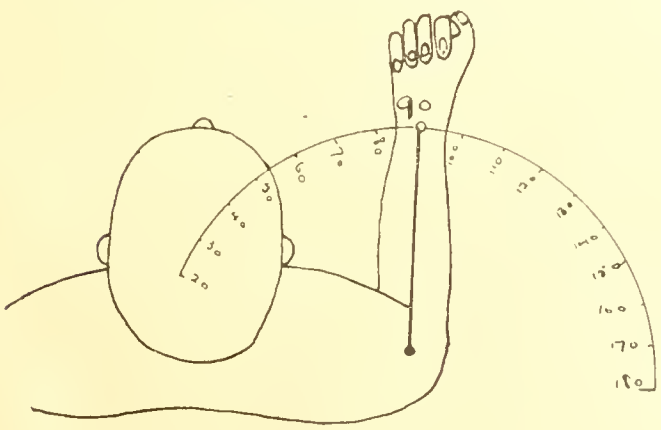


No. 2. Shoulder.
Flexion–extension.

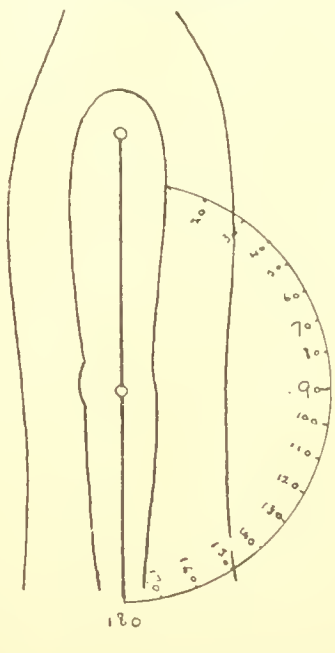


Vancouver) is to be recommended. Such diagrams can be prepared in blank beforehand and pinned to the patient's history when measurements have been recorded on them. A separate diagram for each joint is better than an attempt to depict all movements upon one diagram, because as a rule one patient has limitations of movement confined to one joint.

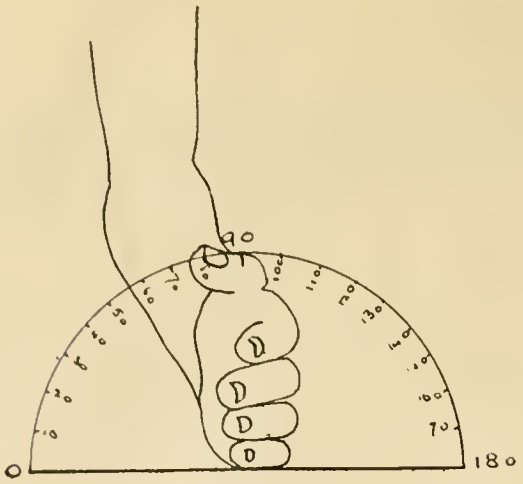
No. 3. Shoulder.
Rotation.



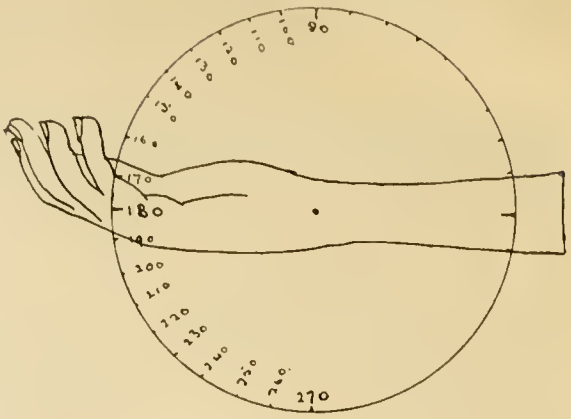
No. 4. Elbow.
Flexion–extension.



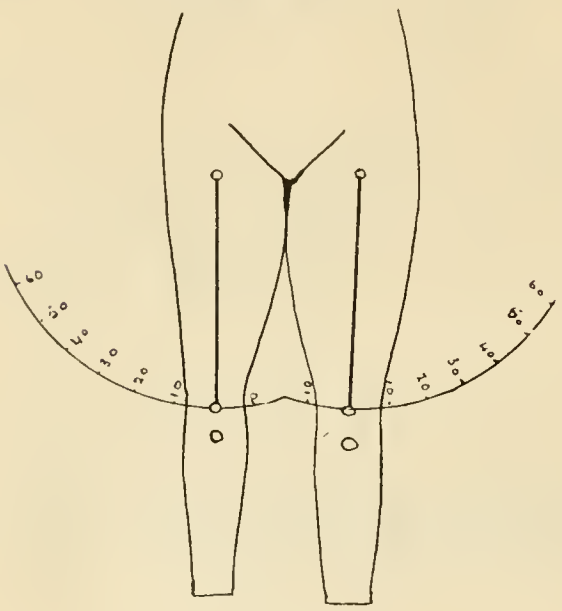
No. 5. Elbow.
Rotation (supination–pronation).



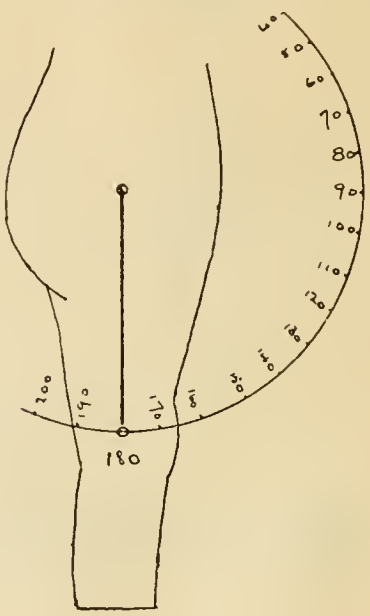
No. 6. Wrist.
Flexion–extension.



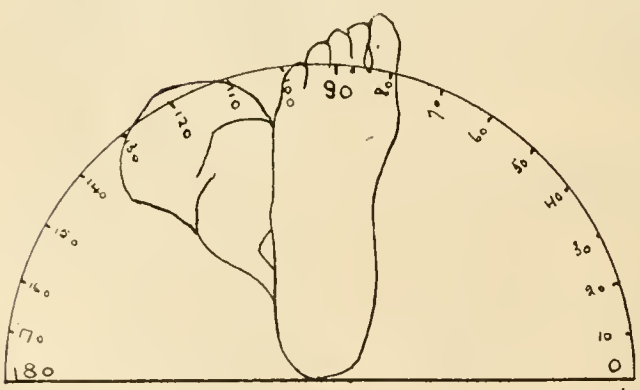
No. 7. Hip.
Abduction–adduction.



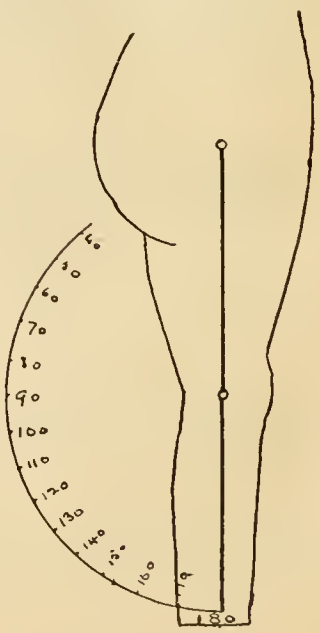
No. 8. Hip.
Flexion–extension.



No. 9. Hip.
Rotation.

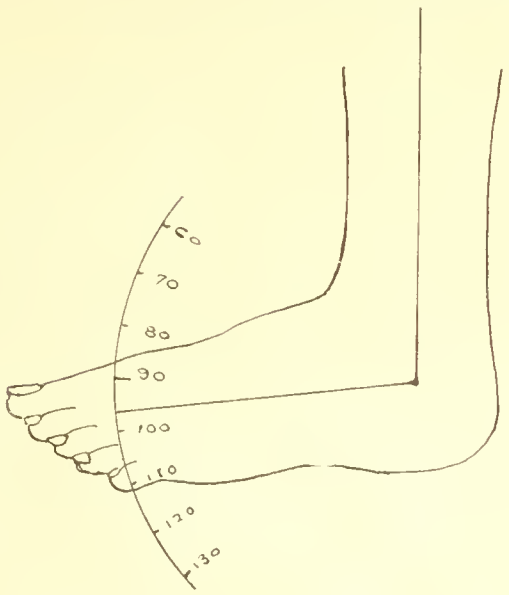


No. 10. Knee.
Flexion–extension.



No. 11. Ankle.

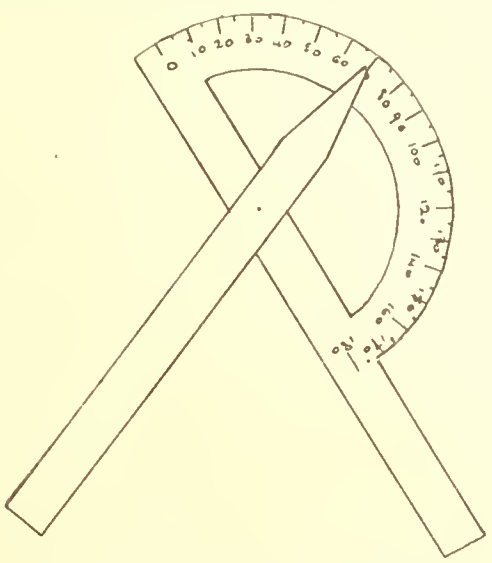
Flexion–extension (i.e., dorsiflexion–plantarflexion).



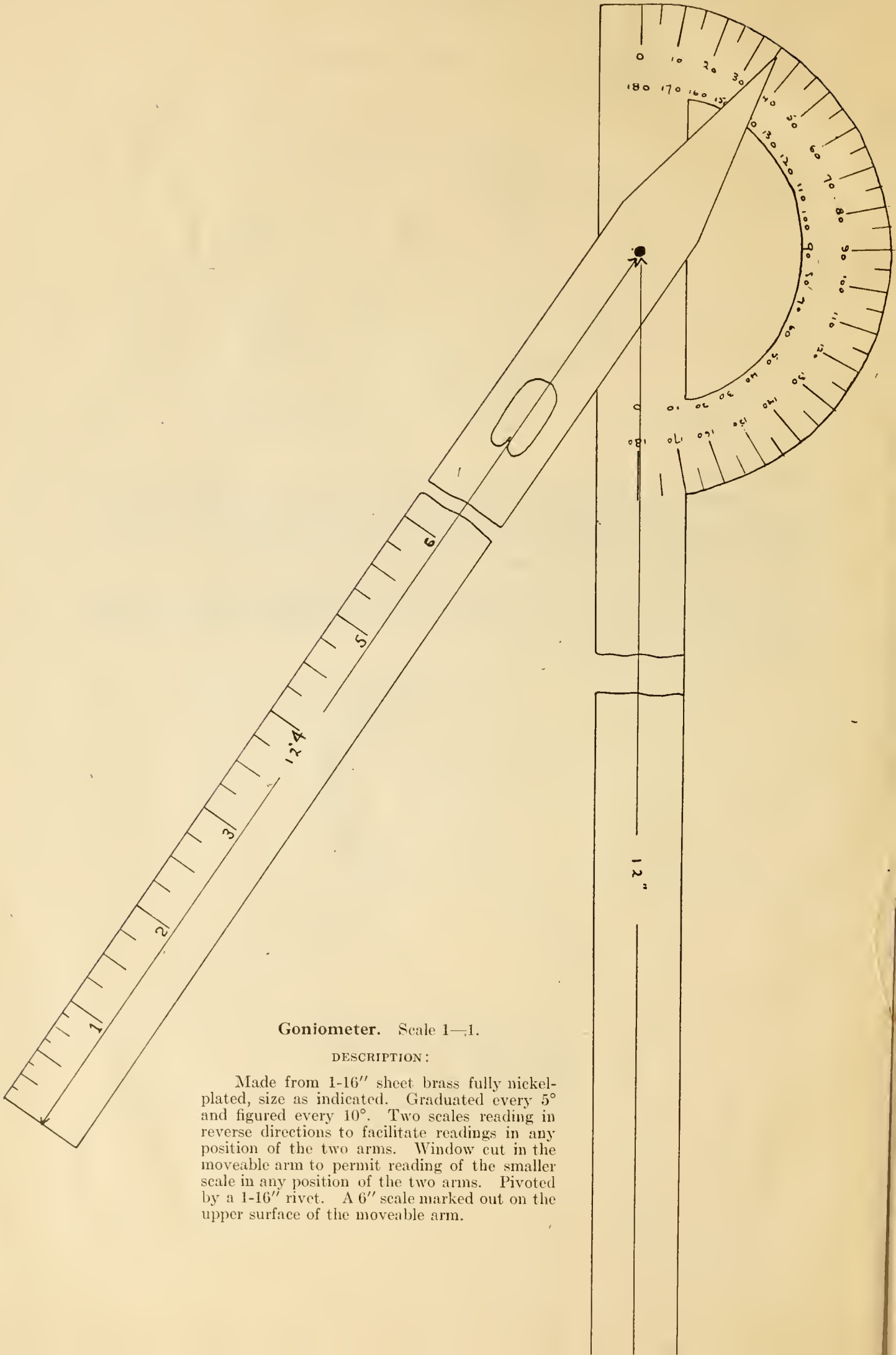
Instruments.

The simple goniometer sketched overleaf is capable of measuring practically all movements of all joints. It can be made by any mechanic of average skill and the cost is trifling. In using it, the arms of the goniometer are lined up by the eye along the axes of the limbs to be examined. By reversing it end for end it is always possible to read one of its two scales in the desired direction. A slight amount of experience renders one proficient in its use.

The smaller replica of it sketched below is useful for measuring the ranges of movement of the joints of the fingers. It is not essential, for such measurements can be made, though with less convenience, with the larger instrument. Because of its limited application it need only have a scale reading in one direction.



Full-size sketch of small goniometer for measuring angles of joints of fingers. Made from 1-16″ sheet brass, nickel-plated, arms 2″ x $\frac{1}{4}$″. Scale marked every 5° and numbered every 10°. Reading one direction only.



Goniometer. Scale 1—1.

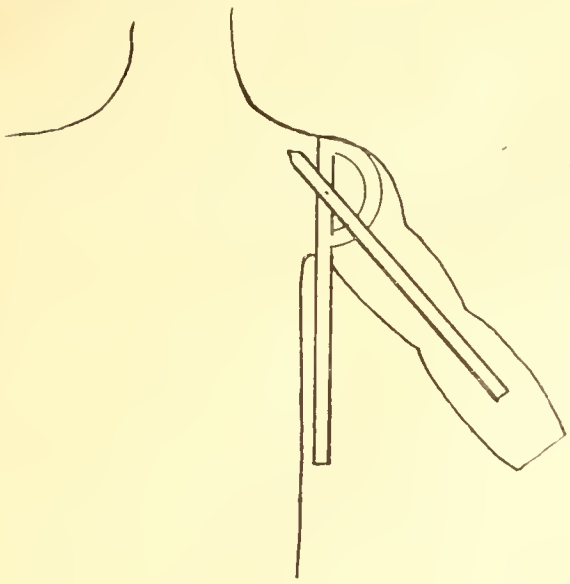
DESCRIPTION:

Made from 1-16″ sheet brass fully nickel-plated, size as indicated. Graduated every 5° and figured every 10°. Two scales reading in reverse directions to facilitate readings in any position of the two arms. Window cut in the moveable arm to permit reading of the smaller scale in any position of the two arms. Pivoted by a 1-16″ rivet. A 6″ scale marked out on the upper surface of the moveable arm.

DETAILS OF METHODS OF MEASUREMENT OF MOVEMENTS AT SPECIFIC JOINTS.

Shoulder, 3 movements.—1. abduction–adduction.
2. flexion–extension.
3. rotation.

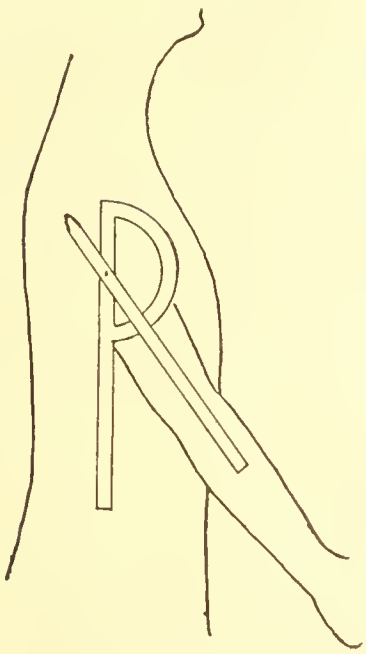
1. Abduction–adduction.



Means of measuring:—

Patient standing erect. One arm of goniometer parallel to edge of trunk, centre of hinge at shoulder joint, second arm down centre of posterior surface of arm: measure from back to avoid bend of forearm. A.G. Adduct. approaches but does not reach zero, usually about 15°. Fix scapula to avoid measuring movement of scapula on thorax.

2. Flexion–extension.

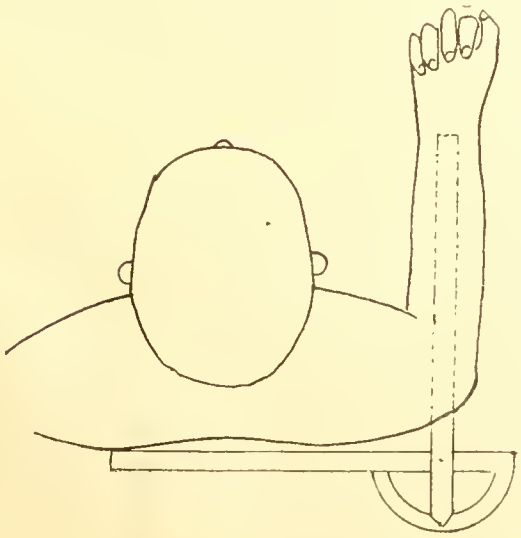


Means of measuring:—

Patient standing erect. Centre of goniometer at shoulder, one arm parallel to central line of trunk, second arm of goniometer down centre line of arm. With arm hanging by the side the position is zero, corresponding to the zero position of the two arms of the goniometer. Angles of flexion (forward movement) then range from zero degrees to 180°, and angles of extension (backward movement) range from 0° to about 90°. To obtain the total range of movement add the two angles together.

It is somewhat difficult to be accurate in this measurement, because the thickness of the shoulder prevents laying the arm of the goniometer directly upon the side of the trunk. It must be held parallel to it and the correctness of its position estimated by line of sight.

3. Rotation.

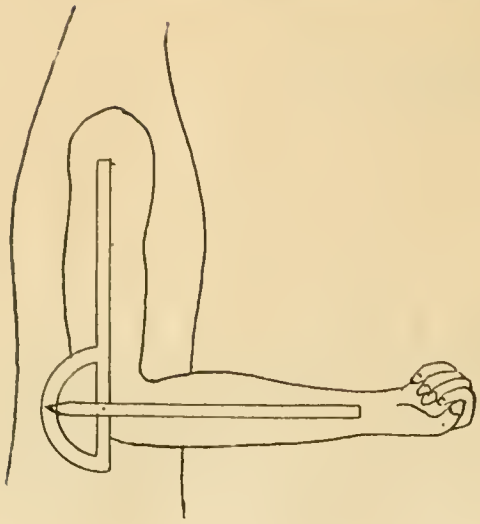


Means of measuring:—

Approximate only. Forearm flexed to 90°, elbow close to body and in line with the back. One arm of goniometer transversely parallel to back, second arm of goniometer along inferior surface of forearm. The mid-position (forearm pointed straight forward) is 90°. As the arm is rotated at the shoulder the forearm swings round and with it the arm of the goniometer. Angles of internal rotation range from 90 ° to 0°, and angles of external rotation range from 90° to 180°.

This method does not permit the measurement of complete internal rotation, but it approximates a correct result. Greater angles of internal rotation than can be measured by this means, can be indicated by a statement of the position into which the patient can put his arm, e.g., he can touch waist-line behind back.

Elbow, two movements.—1. Flexion–extension.
2. Rotation of forearm (supination-pronation).

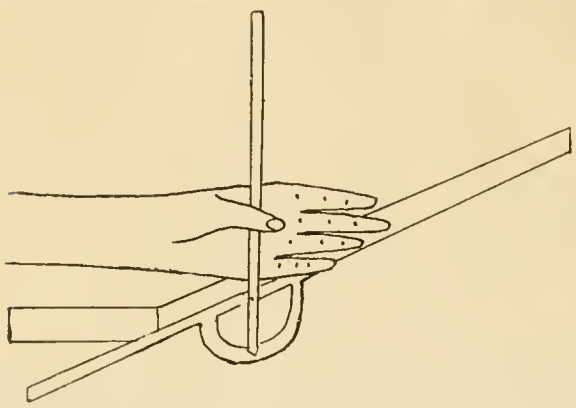


1. Flexion–extension.

Means of measuring:—

Arms of goniometer parallel to axes of arm and forearm and on the lateral surface. Centre of goniometer at elbow. In complete extension the angle between the arm and forearm is 180°.

2. Rotation of forearm (supination–pronation).



Means of measuring:—

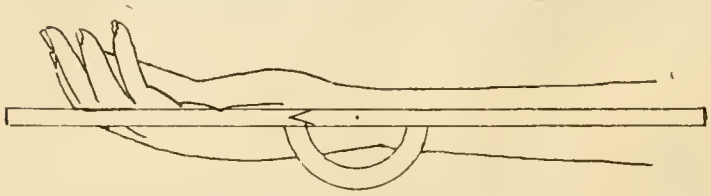
See definition of supination, pronation, and mid-position page 4.

Flex the forearmag 90°; with the hand in the mid-position and the elbow close to the side; place the forearm on the table with half the length of the hand projecting over the edge. Place one arm of the goniometer along the edge of the table-top and the second arm across the palm of the hand. The mid-position will thus be at 90°. Angles of pronation will range from 90° to 0°, and angles of supination will range from 90° to 180°. In carrying out this measurement it is essential that the arm be placed in the position described, otherwise variations are introduced into the measurements. The arm from the elbow up should be at right angles to the table in both the antero-posterior and lateral planes. The elbow in addition should be close to the side.

N.B.—In cases of limitation of the movement supination–pronation, state the cause and site of the cause of limitation, because although this movement is considered here as a function of the elbow joint, it is just as much a function of the forearm and wrist; and injuries there may cause its limitation or loss just as well as injuries at the elbow.

Wrist, two movements.—1. Flexion–extension.
2. Adduction–abduction.

1. Flexion–extension.



Means of measuring:—

One arm of goniometer along ulnar side of forearm, centre at wrist, second arm along the ulnar side of hand. Measure angles of flexion in degrees less than 180°, and angles of extension in degrees greater than 180°.

2. Adduction–abduction. For practical purposes unnecessary to measure.

Fingers.

The complexity of movements at the fingers renders difficult the measurement of their ranges of motion. Moreover, the most important movements of the hand are really complexes of several movements, e.g., the making of the fist involves simultaneous flexion of all the joints of all the fingers, adduction of the fingers, flexion of all the joints of the thumb and its opposition to the other digits. It is obviously difficult to convey an accurate idea of the amount of limitation of such a movement by a recital of the ranges of angular movement of all the joints involved. It is convenient, therefore, in many cases to examine the movements of the joints of the fingers in the manner indicated below and to estimate their limitation in fractions of the normal range without attempting greater accuracy. In other cases, however, especially those in which only one finger is disabled, or where the limitation is confined chiefly to the metacarpo-phalangeal joints, it is of advantage to measure the ranges of movements. For these cases the small goniometer sketched on page 7 is useful.

Method of examining movements of fingers.

Examine the movements of the fingers separately and as a whole under the following headings. Note whether the movements are present or absent, and estimate their range in fractions of normal.

1. The grip (making a fist), flexion of all the joints of all the digits simultaneously together with adduction of the fingers and opposition of the thumb. Estimate the degree of passive and active flexion and note whether there is greater loss in certain fingers than in others.

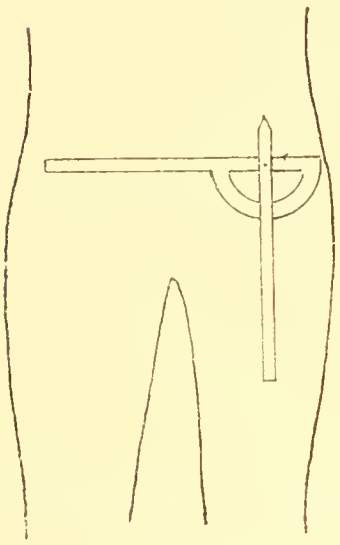
2. Extension, the opposite of 1.

3. Lateral movement (interrosseus power). Distinguish true lateral movement from that which accompanies flexion and extension, and is produced by the action of the flexors and extensors.

4. Simultaneous flexion of the metacarpo-phalangeal joints and extension of the inter-phalangeal joints of the fingers (lumbrical and interrosseus power).

5. Opposition of the thumb to the other digits (opponens power).

Hip, three movements.—1. Adduction abduction.
2. Flexion extension.
3. Rotation.

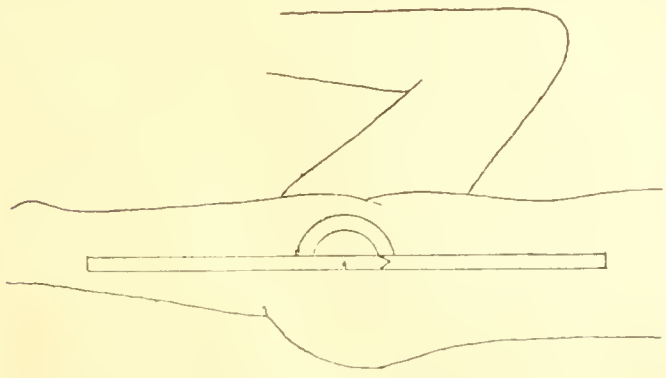


1. Adduction-abduction.

Means of measuring:—

The angle to be measured is that between a line joining the two anterior superior spines of the ilia and the axis of the thigh anteriorly. Place the patient supine, fix the pelvis. One arm of the goniometer along the interspinous line, centre over hip joint, second arm along the centre of thigh anteriorly.

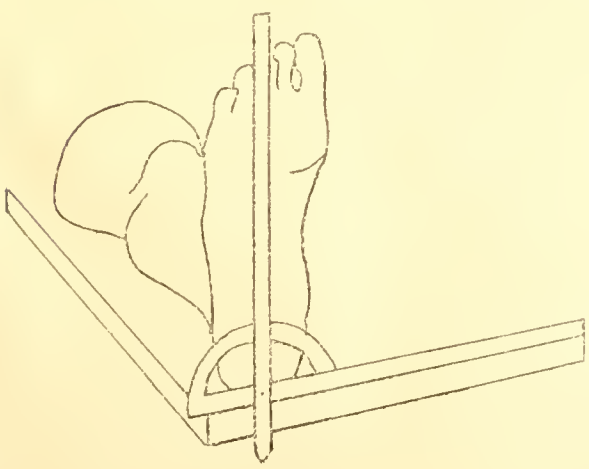
2. Flexion-extension.



Means of measuring:—

Patient supine. With the aid of an assistant fully flex the opposite thigh on the abdomen, so as to overcome the lumbar lordosis and make the line of the spine conform with the surface of the table. Fix the pelvis. One arm of goniometer lies along the axis of the thigh, centre over hip, second arm along the side of trunk. To measure extension, place the patient prone and measure with the goniometer in the same position. If there is no limitation of this movement he should be able to hyperextend 10° beyond the straight line.

3. Rotation.

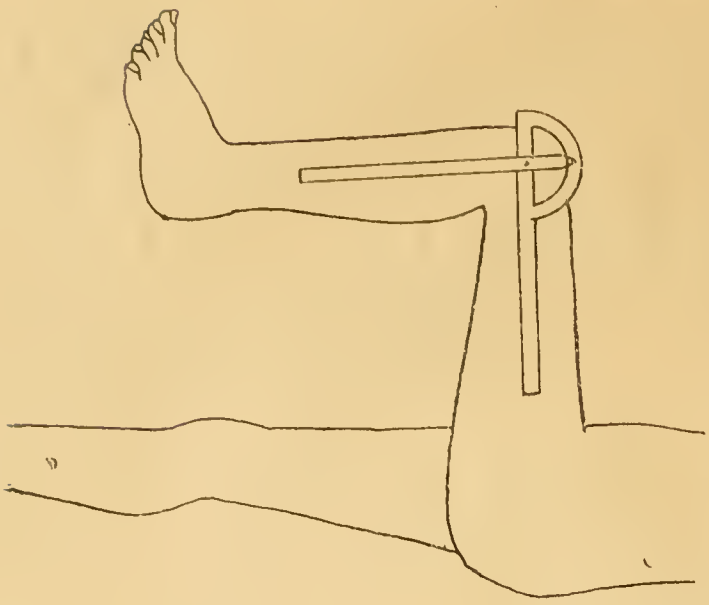


Means of measuring:—

Patient supine, legs extended, feet at right-angles to the table, and mid-line of foot in line with the axis of the leg. Heel at the edge of table. Abduct the leg not being measured out of the way. One arm of goniometer transversely across table at the very edge, second arm of goniometer along sole of foot in the centre line. The mid-position is one in which the two arms of the goniometer are at 90° to one another. Fix the pelvis to prevent its moving.

Knee, two movements.—1. Flexion–extension.
2. Rotation.

1. Flexion–extension.



Means of measuring:—

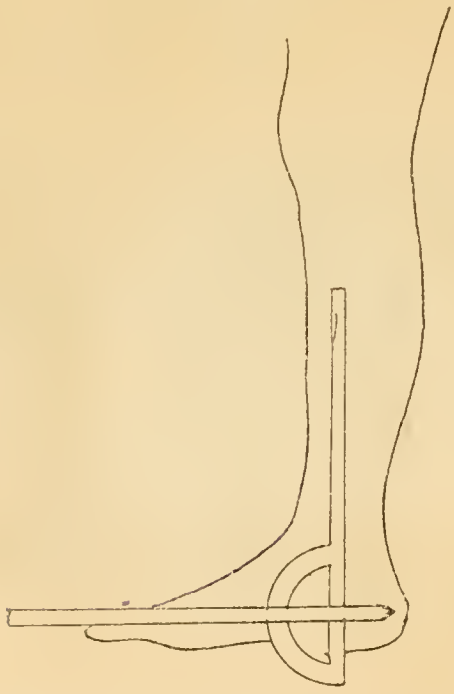
Patient supine. It is necessary to fix the position of the hip in order to prevent variations in the range of movement at the knee made possible by variations in the tension of the ham-strings. The most convenient position for measurement is one in which the thigh of the leg to be measured is flexed to a right angle at the hip. One arm of goniometer lies along outer side of thigh, centre at knee-joint; second arm of goniometer lies along outer side of leg.

2. Rotation.

For practical purposes unnecessary to measure.

Ankle, one movement.—Flexion–extension.

1. Flexion–extension (i.e., dorsiflexion–plantarflexion).



Means of measuring:—

Patient supine. Keep the knee extended to avoid the increased flexion of the ankle which is permitted by full flexion of the knee. One arm of protractor along fibula, center at ankle-joint, second arm along outer side of foot parallel to the sole.

Foot, two movements.—1. Adduction–abduction.
2. Supination–pronation.

Both movements take place at the mid-tarsal joint, and usually supination simultaneously with adduction, and pronation with abduction. It is not possible to measure them by any simple means. For practical purposes they may be estimated in fractions of the normal side.

Spine, three movements.—1. Flexion in the antero-posterior plane.
2. Lateral bending.
3. Rotation.

All movements of the spine are the sum of numerous small movements between the individual vertebræ. For this reason and also because of the difficulty of applying instruments to the back, it is not practicable for ordinary purposes to measure them in degrees. Any limitations should be noted, and their extent estimated in terms of normal.

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